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Reaction of Some Species of Nicotiana to Tobacco Mosaic Virus, Tobacco Streak Virus, Pseudomonas Tabaci, and Phytophthora Parasitica var. Nicotianae

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Reaction of Some Species of Nicotiana to Tobacco Mosaic Virus, Tobacco Streak Virus, Pseudomonas Tabaci, and Phytophthora Parasitica Var. Nicotianae

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In connection with the program for the development of tobacco resistant to diseases common in Kentucky, the available species of *Nicotiana* were tested for resistance to tobacco mosaic virus, tobacco streak virus, *Pseudomonas tabaci*, the wildfire organism, and *Phytophthora parasitica* var. *nicotianae*, the black shank organism. Seed of most of the species was kindly furnished by Dr. T. H. Goodspeed, University of California, and Dr. E. E. Clayton of the Bureau of Plant Industry, U. S. Department of Agriculture.

TOBACCO MOSAIC

Allard (1914)* inoculated several species of Nicotiana with tobacco mosaic virus, with the following results: *N. alata, N. forgetiana, N. langsdorffii, N. longiflora, N. paniculata, N. plumbaginifolia, N. rustica, and N. sylvestris* became diseased. Mottling occurred in *N. longiflora, N. plumbaginifolia,* and *N. sysvestris.* Some plants of *N. rustica* were killed; others were stunted and "savoyed." *N. langsdorffii* at first appeared immune, but when inoculated through the stalk or petiole showed a progressive and destructive necrosis. *N. glutinosa* behaved in a similar manner. *N. glauca* did not show symptoms but carried the virus.

Holmes (1929-1946) described or listed the reaction of 36 species of *Nicotiana.* Mottling or mosaic occurred in most of the species: *N. acuminata, N. benthamiana, N. bigelovii, N. bonariensis, N. caudigera, N. clevelandii, N. debneyi, N. eastii, N. exigua, N. gossei, N. longiflora, N. maritima, N. megalosiphon, N. nudicaulis, N. occidentalis, N. otophora, N. palmeri, N. plumbaginifolia, N. rotundifolia, N. solanifolia, N. suaveolens, N. sylvestris, N. tomentosa, N. tomentosiformis, N. trigonophylla,* and *N. velutina.* Some plants of *N. alata* and *N. undulata* became mottled, whereas others became systemically necrotic. In *N. bigelovii* and *N. clevelandii* severe stunting and yel-

* Refers to "Literature Cited," page 12.

lowing preceded mottling. Plants of *N. glauca* showed faint mottling at first; later the mottling disappeared in some cases, and in such plants the virus was present in some and absent in others. Some plants of *N. raimondii* showed mottling, while others did not although virus was present in the tissues. Local necrotic lesions developed on rubbed leaves of *N. acuminata* (at least one strain), *N. glutinosa, N. langsdorffii, N. repanda,* and *N. rustica,* sometimes followed by systemic necrosis. (Some plants of *N. alata* and *N. undulata* also developed necrotic lesions). *N. nudicaulis* showed chlorotic stunting. In *N. wigandioides* no symptoms developed, and virus was present only in inoculated leaves.

Valleau (1935) found that the nature of local and systemic symptoms in *N. sanderae* depended to some extent on the strain of the virus. In *N. langsdorffii* mosaic occurred with some strains of the virus.

Commercial varieties of mosaic-resistant burley tobacco have been developed from crosses between *N. glutinosa* and tobacco (Holmes, 1938; Valleau, 1942).

Procedure

Young plants were inoculated in the greenhouse by rubbing two or three leaves with plant extract prepared from burley tobacco infected with a yellowing strain of tobacco mosaic virus that produces mottle on N′ N′ and n′ n′ varieties of tobacco, but necrotic spots on N N varieties when N is derived from *N. glutinosa* (Valleau and Johnson, 1943). Usually 10 plants of a species were inoculated; if results were inconclusive, additional plants were inoculated later if the plants were available.

Results

Mottling was the dominant symptom in *N. acuminata, N. arentsii, N. attenuata, N. cordifolia, N. exigua, N. knightiana, N. longiflora, N. megalosiphon, N. otophora, N. palmeri, N. plumbaginifolia, N. setchellii, N. sylvestris, N. tabacum, N. tomentosa, N. tomentosiformis,* and *N. trigonophylla* (mottle was mild in *N. cordifolia,* and slow to develop in *N. setchellii* and *N. tomentosiformis*). Some plants of *N. alata, N. bonariensis, N. langsdorffii,* and *N. maritima* became mottled, while others became systemically necrotic or remained symptomless. Chlorosis or yellowing and stunting, often followed by mottling or by necrosis, was the chief symptom in *N. benthamiana, N. bigelovii, N. clevelandii, N. debneyi, N. nudicaulis, N. occidentalis, N. pauciflora* and *N. rotundifolia* (some plants of *N. benthamiana* became systemically necrotic).

Some plants of *N. glauca* developed mild mottling, while others showed no symptoms. *N. raimondii* showed only yellow blotches in old leaves. *N. benavidesii* showed no symptoms; virus was recovered from inoculated leaves but not from upper leaves. In *N. fragans* distortion occurred without mottling.

Local necrotic spots or blotches, often followed by systemic necrosis, developed on rubbed leaves of *N. corymbosa*, *N. glutinosa*, *N. goodspeedii*, *N. paniculata*, *N. repanda*, and *N. rustica*, and in some plants of the four species listed above as being mottled at times (*N. alata*, *N. bonariensis*, *N. langsdorffii*, and *N. maritima*). Local necrotic spots without subsequent systemic infection developed in *N. gossei*, *N. nesophila*, *N. stocktoni*, *N. suaveolens*, *N. undulata*, and *N. velutina*.

Differences in reaction reported here and those reported previously (*N. bonariensis*, *N. gossei*, *N. langsdorffii*, *N. maritima*, *N. paniculata*, *N. suaveolens*, and *N. velutina*) may have been due to difference in strains of the virus, temperature differences at the time of inoculation, variations among members of a species, or improper identification of species.

STREAK

Johnson (1937) reported that *N. tabacum*, *N. sylvestris*, and *N. repanda*, inoculated with the streak virus, produced typical systemic acute necrosis followed by "recovery." In contrast *N. acuminata*, *N. glutinosa*, *N. nudicaulis*, *N. longiflora*, and *N. bigelovii* produced no necrotic symptoms, but only mottling from which "recovery" was not evident. *N. alata grandiflora* tended to produce a chlorotic type of symptom. *N. quadrivalvis* var. *multivalvis*, *N. paniculata* and *N. rustica* produced very mild if any symptoms; evidently they possessed a natural resistance to both the mottling and the necrotic form of the disease.

Berkeley and Phillips (1943) reported that *N. tabacum*, *N. rustica*, *N. sylvestris*, *N. langsdorffii*, and *N. bigelovii* were susceptible, but *N. glauca* failed to develop symptoms.

A report of part of the present work has been published in abstract form (1947).

Procedure

Young plants were inoculated in the greenhouse by rubbing 2 or 3 carborundum-dusted leaves with plant extract prepared by crushing young chronically infected leaves of *N. rustica* with an approximately equal volume of M/10 Na_2HPO_4 (Diachun and Valleau, 1950). Inoculated leaves were rinsed with tap water. Usually 10

plants of a species were inoculated; if results were inconclusive additional plants were inoculated later if they were available. The strain of the virus used seemed to be rather virulent.

Results

From Table 1 it is apparent that most of the species of *Nicotiana* are susceptible to streak. A few are even more susceptible than burley tobacco – *N. paniculata, N. repanda, N. miersii, N. clevelandii, N. megalosiphon, N. occidentalis, N. benthamiana,* and *N. rotundifolia.* A few species, however, offer promise as resistant stocks in breeding streak-resistant tobacco, especially *N. glauca,* and perhaps *N. raimondii, N. cordifolia, N. maritima,* and *N. gossei.*

WILDFIRE

Johnson, Slagg, and Murwin (1924) inoculated twelve species of *Nicotiana* with *Pseudomonas tabaci.* All the species "proved to be uniformly susceptible to wound inoculations, although fairly marked differences occurred when the organism was applied by atomizer only."

Anderson (1925) tested the reaction of 18 species of *Nicotiana.* *N. rustica, N. alata, N. repanda, N. nudicaulis,* and *N. attenuata* were resistant, and *N. bigelovii, N. longiflora,* and *N. suaveolens* showed some resistance.

Clayton (1934) showed that introduction of toxin produced by *P. tabaci* may give misleading results regarding resistance, for many resistant species of plants are very susceptible to the toxin.

In an abstract Clayton and Foster later reported that some 30 species of *Nicotiana* were studied with respect to disease resistance (1940). *N. debneyi* and *N. repanda* were found to be resistant to wildfire.

More recently Clayton (1947, 1948), and Valleau (1948) reported the development of wildfire-resistant tobacco from hybrids with *N. longiflora.*

Procedure

In the present study, in most species at least 10 plants were inoculated. When the reaction was not considered definite, inoculations were repeated. To reduce the possibility of introducing toxin into plants, 24-hour broth cultures diluted 1 to 1000 were usually used. Inoculations were made on several leaves of greenhouse plants, either by atomizing the lower surface with the suspension of bacteria or,

more often, by water-soaking the leaves with a stream of water from a hypodermic syringe and then pouring the bacterial suspension onto the lower surface.

Results

Most of the species were about as susceptible as burley tobacco. *Nicotiana cordifolia*, *N. undulata*, *N. gossei*, and to a lesser extent *N. glauca*, *N. benthamiana*, *N. velutina*, and *N. exigua* developed more necrosis and less chlorosis than tobacco. *N. benavidesii* reacted like these species, but in addition systemic chlorosis usually occurred in the young upper leaves. In *N. paniculata* the chlorotic halos surrounding necrotic areas were wider than on tobacco.

Several species were resistant: *N. alata*, *N. longiflora*, *N. plumbaginifolia*, *N. repanda*, *N. arentsii*, and *N. bonariensis*. In all these species there was some variation among plants, some of the plants developing a few wildfire spots.

It is interesting that most members of the section Paniculatae seem more susceptible or more sensitive to *P. tabaci* than tobacco, and that most of the resistant species belong to the section Alatae (Table 1).

BLACK SHANK

Foster, who tested 13 species of *Nicotiana* for resistance to black shank (1943), reported that under the severe conditions of his experiments no species was immune. *N. repanda*, *N. rustica*, and *N. longiflora* showed definite resistance to black shank. In *N. repanda* resistance appeared to be located primarily in the roots.

Kincaid (1949) reported that in field tests at Quincy, Florida, *N. repanda* and *N. plumbaginifolia* were moderately resistant to black shank.

Procedure

Small seedlings were inoculated in the greenhouse by pouring into the seedpots in which the seedlings were growing a suspension of zoospores and mycelial fragments in water. Susceptible plants were killed in such tests.

Results

Most of the species were susceptible. *N. alata*, *N. bonariensis*, *N. longiflora*, *N. nudicaulis*, *N. plumbaginifolia*, and *N. repanda* were resistant or immune; at least, no seedlings of these species died under conditions that resulted in death of all seedlings of susceptible species.

Table 1.— Reaction of species[a] of Nicotiana to tobacco mosaic virus, tobacco streak virus, Pseudomonas tabaci and Phytophthora parasitica var. nicotianae

Species	Mosaic symptoms		Streak symptoms		Reaction to *Pseudomonas tabaci*	Reaction of seedlings to *P. parasitica* var. *nicotianae*
	Local	Systemic	Local	Systemic		
Section Paniculatae						
N. paniculata	Chlorosis and vein necrosis	Stunting, and necrotic blotches, or none	Necrotic spots	Severe necrotic streak; dwarfing in chronic stage	Very susceptible; halos wider than on tobacco	Susceptible
N. knightiana	Chlorotic spots	Mild mottle	Few necrotic rings	Streak; little stalk necrosis	Susceptible; lesions larger than on tobacco	Susceptible
N. benavidesii	None (virus present)	None (no virus)	Finely necrotic rings	Mild streak; no stalk necrosis; dwarfing in chronic stage	Very susceptible; severe necrosis; systemic toxicity; slow halo formation	Susceptible
N. raimondii	None	None, or yellow blotches in old leaves	Few necrotic rings	Mild streak	Susceptible; typical wildfire	
N. cordifolia	None, or chlorosis	Mild mottle	Few necrotic spots	Very mild streak; only scattered necrotic spots	Very susceptible; severe necrosis; slow halo formation	
N. glauca	None	None, or mild mottle	Very few necrotic spots	No symptoms, or mild mottle in occasional plant	Susceptible; slow halo formation	Susceptible
Section Rusticae						
N. rustica	Necrotic spots	Systemic necrosis	Necrotic spots and rings	Moderate streak; little or no stalk necrosis	Susceptible; more necrosis and less halo than on tobacco	Susceptible
Section Tomentosae						
N. tomentosa	Chlorosis	Mottle	Necrotic spots	Mild streak	Susceptible; typical wildfire	Susceptible
N. tomentosiformis	Chlorosis	Mottle, slow invasion	Necrotic spots and rings	Streak, somewhat mild	Susceptible; typical wildfire	Susceptible

[a] Seed of 8 of the 58 species listed by Goodspeed (1) was not available (*N. acaulis, N. ameghinoi, N. excelsior, N. ingulba, N. petunioides, N. spegazzinii, N. stenocarpa, N. thyrsiflora*). Seed of 2 did not germinate (*N. solanifolia* and *N. wigandioides*). Seed of *N. miersii* and *N. linearis* did not produce enough plants for a good test. Only 2 plants of *N. noctiflora* grew; they did not produce seed; seed is no longer available.

Table 1 (Continued)

Species	Mosaic symptoms		Streak symptoms		Reaction to *Pseudomonas tabaci*	Reaction of seedlings to *P. parasitica* var. *nicotianae*
	Local	Systemic	Local	Systemic		
N. otophora	Chlorosis	Mottle	Necrotic spots and rings	Mild streak; no necrosis	Susceptible; lesions smaller than on tobacco	Susceptible
N. setchellii	Chlorosis	Mottle; slow invasion	Necrotic spots and rings	Mild streak	Susceptible; lesions smaller than on tobacco	
N. glutinosa	Necrotic spots	Systemic necrosis, or none	Necrotic spots and rings	Moderate streak	Susceptible; lesions smaller than on tobacco	Susceptible
Section Genuinae						
N. tabacum	Chlorosis	Mottle	Numerous necrotic spots	Streak	Susceptible; typical wildfire	Susceptible
Section Undulatae						
N. undulata	Necrotic spots	None	Few necrotic spots	Streak; yellowing and dwarfing in chronic stage	Very susceptible; severe necrosis; slow halo formation	Susceptible
N. arentsii	Chlorosis	Mottle	Necrotic rings	Streak; relatively mild	Resistant, but some plants moderately susceptible	Susceptible
Section Trigonophyllae						
N. trigonophylla	Chlorosis	Mottle	Few necrotic spots	Streak	Susceptible; typical wildfire	Susceptible
N. palmeri	None	Mottle	Few necrotic rings	Mild streak; not all plants systemically infected	Susceptible; typical wildfire	Susceptible
Section Alatae						
N. alata	None, or chlorosis, or necrotic spots	Mottle, or systemic necrosis, or none	Fine necrotic rings	Moderate or mild streak; no stalk necrosis	Resistant, but some plants moderately susceptible	Immune
N. langsdorffii	Chlorotic spots	Mottle, with or without necrosis	Few necrotic rings	Mild streak; no stalk necrosis	Susceptible; typical wildfire	
N. bonariensis	Chlorotic spots, or none	Mild mottle, or systemic necrosis	Few necrotic rings	Mild streak	Resistant, but some plants moderately susceptible	Immune

Table 1 (Continued)

Species	Mosaic symptoms		Streak symptoms		Reaction to *Pseudomonas tabaci*	Reaction of seedlings to *P. parasitica* var. *nicotianae*
	Local	Systemic	Local	Systemic		
N. longiflora	Chlorosis	Mottle	Necrotic rings	Moderate or mild streak; no stalk necrosis	Resistant; some plants produce a few lesions	Immune
N. plumbaginifolia	Chlorosis, with or without necrosis	Mottle	Necrotic rings	Streak	Resistant; some plants produce lesions	Immune
N. sylvestris	Chlorosis	Mottle	Necrotic spots and rings	Streak	Susceptible; typical wildfire	Susceptible
N. repanda	Necrotic spots	Systemic necrosis, or none	Necrotic spots	Severe streak; yellowing and dwarfing in chronic stage	Moderately resistant; lesions smaller and less numerous than on tobacco	Immune
N. stocktonii	Necrotic spots	None	Few necrotic spots	Streak	Susceptible; typical wildfire	Susceptible
N. nesophila	Necrotic spots	None	Fine necrotic rings	Mild streak; no stalk necrosis	Susceptible; typical wildfire	Susceptible
Section Noctiflorae						
N. noctiflora[a]					Susceptible; halos somewhat more narrow than on tobacco	
Section Acuminatae						
N. attenuata	Chlorosis and necrosis	Mottle			Susceptible; typical wildfire	
N. acuminata	Chlorosis	Mottle	Necrotic spots	Relatively mild streak	Susceptible; typical wildfire	Susceptible
N. pauciflora	Chlorosis	Chlorosis; later mottle	Necrotic spots	Streak	Susceptible; typical wildfire	Susceptible
N. corymbosa	Necrotic spots	Systemic necrosis	Necrotic spots	Streak; no necrosis in crown	Susceptible; typical wildfire	
N. miersii[a]			Necrotic spots	Severe necrotic streak; plants killed		
N. linearis[a]			Few necrotic spots	Streak; no necrosis in crown	Susceptible; typical wildfire	
N. clevelandii	Chlorosis	Chlorosis and mottle	Necrotic spots	Severe necrotic streak; many plants killed	Susceptible; typical wildfire	Susceptible

Table 1 (Continued)

Species	Mosaic symptoms		Streak symptoms		Reaction to *Pseudomonas tabaci*	Reaction of seedlings to *P. parasitica* var. *nicotianae*
	Local	Systemic	Local	Systemic		
N. bigelovii	Chlorosis	Chlorosis and mottle	Necrotic spots and rings	Streak	Susceptible; typical wildfire	Susceptible
N. nudicaulis	Chlorosis	Chlorosis, stunting, mottle	Necrotic rings	Mild streak; no stalk necrosis	Susceptible; typical wildfire	Immune
Section Suaveolentes						
N. suaveolens	Necrotic spots	None	Few necrotic spots	Mild streak	Susceptible; typical wildfire	Susceptible
N. maritima	Necrotic spots, or none	Mottle, or systemic necrosis, or none	Few necrotic rings	Mild streak	Susceptible; lesions less numerous than on tobacco	Susceptible
N. velutina	Necrotic spots	None	Necrotic spots	Streak	Very susceptible; more necrosis than on tobacco	Susceptible
N. exigua	None, or necrotic blotches	Mottle	Necrotic spots	Severe streak	Susceptible; more necrosis and less chlorosis than on tobacco	Susceptible
N. gossei	Necrotic spots	None	Few necrotic rings	Very slow invasion; mild streak in few plants	Very susceptible; severe necrosis; slow halo formation	Susceptible
N. benthamiana	Chlorosis	Severe stunting; chlorosis; sometimes mottle; sometimes systemic necrosis	Necrotic spots	Severe streak; some plants killed	Susceptible; more necrosis than on tobacco	Susceptible
N. megalosiphon	Chlorotic spots	Mottle	Necrotic spots	Severe streak; most plants killed	Susceptible; typical wildfire	Susceptible
N. goodspeedii	Necrosis	Systemic necrosis, or none	Necrotic rings	Streak	Susceptible; typical wildfire	Susceptible
N. occidentalis	Chlorosis with some necrosis	Chlorosis, dwarfing, mottle with necrosis	Necrotic spots and rings	Severe streak	Susceptible; typical wildfire	Susceptible
N. rotundifolia	Chlorosis and necrosis	Chlorosis, dwarfing, mottle	Necrotic spots and rings	Severe streak	Moderately resistant; lesions smaller and less numerous than on tobacco	Susceptible
N. debneyi	Chlorotic spots	Chlorosis; mild mottle	Necrotic spots	Streak	Susceptible; typical wildfire	Susceptible
N. fragrans	None	Distortion	Few necrotic spots	Streak; no stalk necrosis	Susceptible; lesions somewhat smaller than on tobacco	Susceptible

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